DIGITAL DISPLAY OF ACOUSTIC HOLOGRAPHIC IMAGES

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ABSTRACT

Acoustic holography is an elegant and accurate technique for characterizing defects by forming visual images of them. Traditionally, optical reconstruction methods have been used to display the images but due to constraints of the optical systems, digital reconstruction techniques are now being employed.

INTRODUCTION

Optical reconstruction of scanned acoustic holographic information on a transparency is accurate and relatively flexible but it suffers from various constraints due to the magnification factor that must be applied to the reconstructed defect images. These constraints limit the ease in interpreting defect images for the purpose of characterization.

The major influences on the magnification factor for the optical image are the dependence on the depth of the defect in the material and the frequency of the interrogating sound beam. Reconstructions of a test block with flat bottom holes in the shape of a "Y" pattern at different inspection frequencies shows the effect directly.

Computer reconstruction of acoustic holograms eliminates most of the display problems associated with optical images because the image size is no longer directly dependent on frequency or defect depth. The only limitations are from the particular display device being used. Eliminating the magnification factor variables make it possible to create images that are composites of several images as functions of depth, frequency, or just displacement on the inspection surface. Display and fitting together of images taken at different inspection angles can be used to create three-dimensional views of defects also.

To make composite images meaningful, all the images must be made relative. The method we use is to form binary images and then threshold the noise portion out of the image before forming any composites. A means of systematically determining the "best" threshold for each image has been developed and is being expanded in use.

ULTRASONIC HOLOGRAM FORMATION BY A
SCANNED TIME GATED PULSE-ECHO SYSTEM

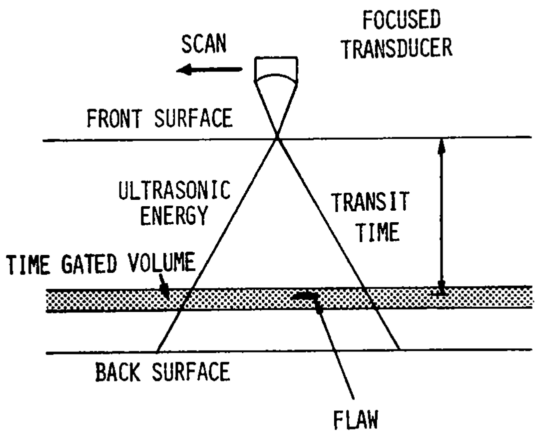
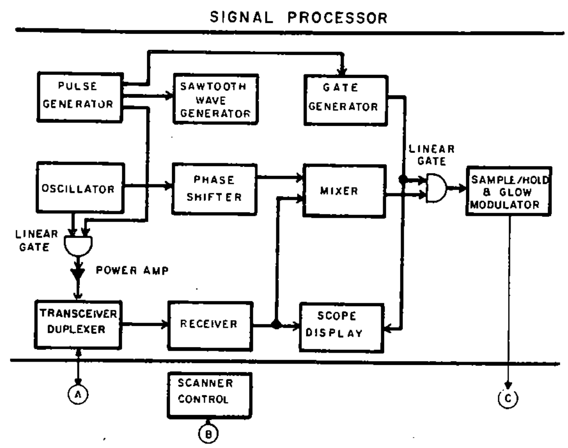


FIGURE 1: SCANNING TRANSDUCER GEOMETRY

FIGURE 2: ELECTRONIC PROCESSOR SCHEMATIC



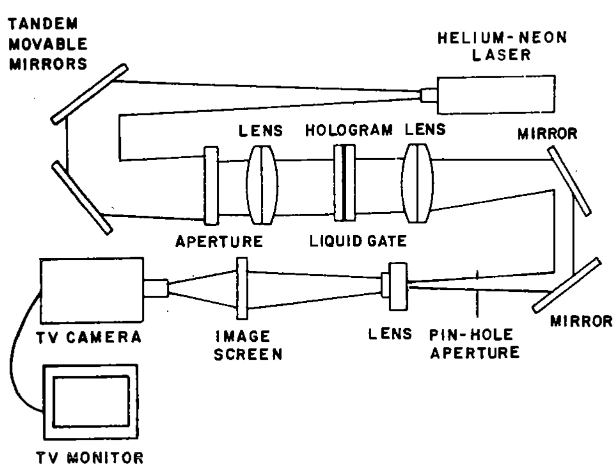


FIGURE 3: OPTICAL IMAGE RECONSTRUCTION

THE IMAGE MAGNIFICATION FACTOR IS GIVEN BY:

$$M = (\alpha * F) / (\nu_M * R_1)$$

WHERE

α = constant

F = ultrasonic frequency

ν_m = sound velocity in the material

R_1 = sound travel path to defect

OPTICAL RECONSTRUCTION OF TEST BLOCK IMAGES

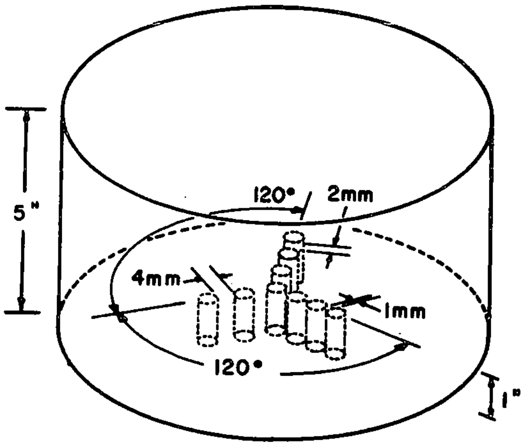


FIGURE 4: ALUMINUM TEST BLOCK SCHEMATIC

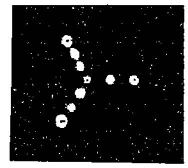


FIGURE 5: 3 MHz OPTICAL IMAGE

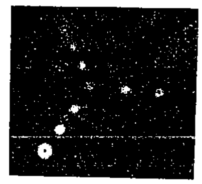


FIGURE 6: 5 MHz OPTICAL IMAGE

TABLE 1: DISADVANTAGES OF OPTICAL IMAGE RECONSTRUCTION

A) FINAL IMAGE SIZE IS DEPENDENT ON DEFECT DEPTH, INSPECTION FREQUENCY AND MATERIAL VELOCITY.

B) DEFECT SIZING IS DEPENDENT ON OPERATOR JUDGEMENT AS TO "BEST" IMAGE.

C) COMPOSITE IMAGES FROM DIFFERENT DEPTHS AND/OR FREQUENCIES ARE VERY DIFFICULT TO CREATE.

D) OPTICAL BENCH SET-UP AND ADJUSTMENT REQUIRE A SKILLED OPERATOR.

TABLE 2: ADVANTAGES OF DIGITAL IMAGE RECONSTRUCTION.

A) ELIMINATION OF IMAGE SIZE ON DEFECT DEPTH, FREQUENCY AND MATERIAL VELOCITY.

B) COMPOSITE IMAGE FORMATION FROM DIFFERENT DEFECT DEPTHS AND/OR INSPECTION FREQUENCIES.

C) IMAGE ENHANCEMENT USING DIGITAL TECHNIQUES.

D) DEVELOPMENT OF "INTELLEGENT" IMAGING HARDWARE.

E) EVENTUALLY WILL BE ABLE TO DO NEAR REAL-TIME IMAGING.

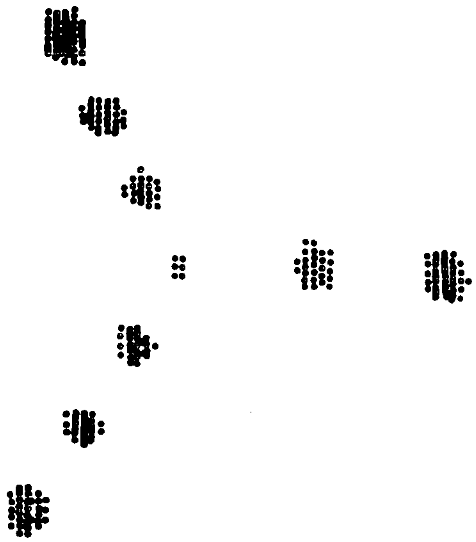


FIGURE 7: DIGITAL TEST BLOCK IMAGE FIVE TIMES ACTUAL SIZE

FIGURE 8: DIGITAL TEST BLOCK IMAGE TWICE ACTUAL SIZE

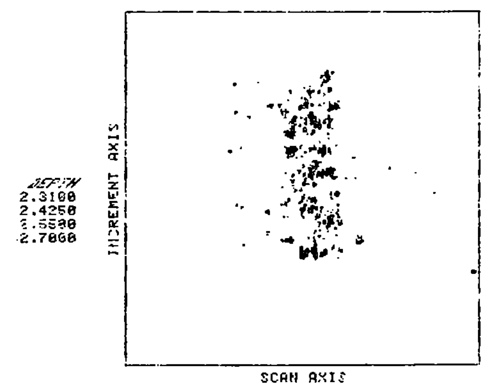


FIGURE 9: DEPTH COMPOSITE OF ACTUAL DEFECT AFTER DIGITAL IMAGE RECONSTRUCTION

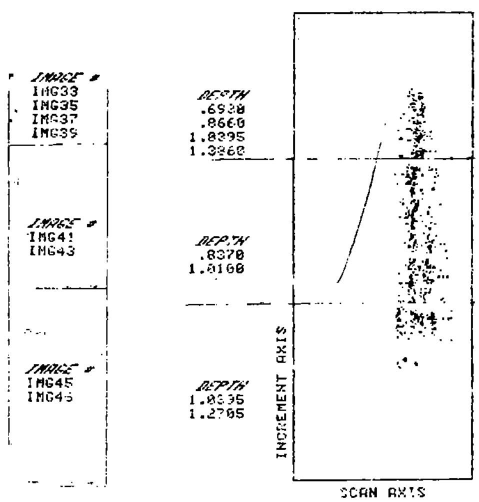


FIGURE 10: DEPTH AND LOCATION COMPOSITE OF AN ACTUAL DEFECT THAT WAS LARGER THAN THE SCANNER APERTURE.

TOTAL LENGTH = 9.4 INCHES

TOTAL WIDTH = 1.45 INCHES

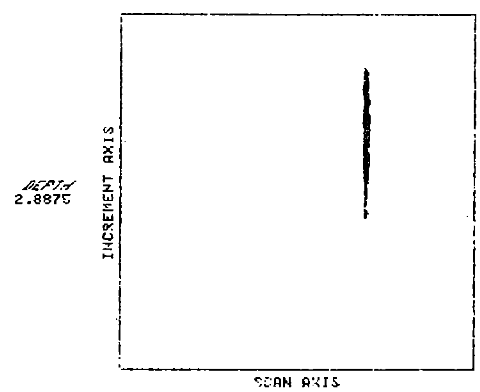


FIGURE 11: RECONSTRUCTED IMAGE OF A SIDE-DRILLED HOLE: LENGTH AND WIDTH ARE DIRECTLY MEASURABLE FROM THE IMAGE.

LENGTH = 2.55"

WIDTH = 0.13"

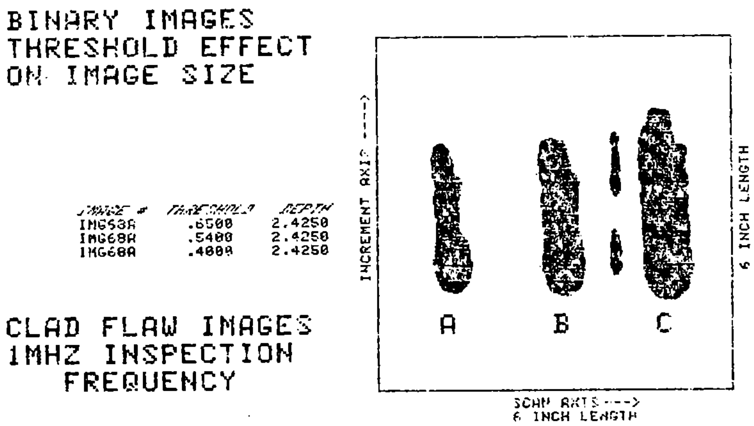


FIGURE 12: THRESHOLD EFFECT, FOR NATURAL DEFECTS. ONE PRESSING PROBLEM IS IMAGE QUALITY CRITERIA. WHAT IS THE "BEST" IMAGE DISPLAY THAT CORRECTLY SIZES THE DEFECT.

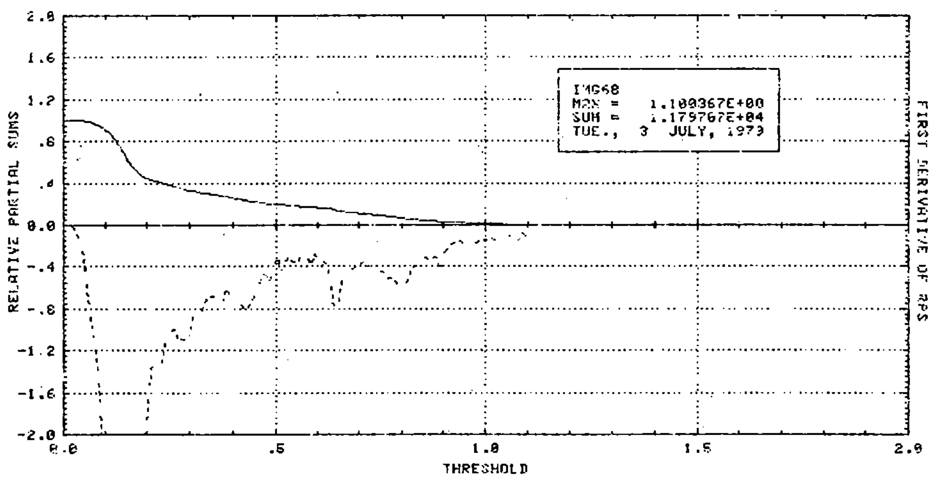


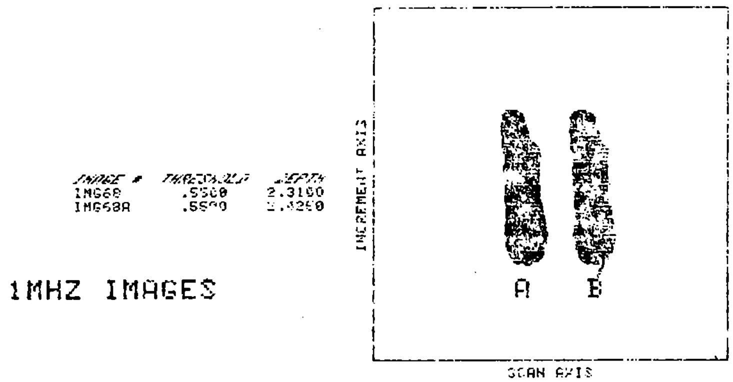
FIGURE 13: RELATIVE PARTIAL SUMS (RPS) PLOT TO DETERMINE "BEST" IMAGE DISPLAY

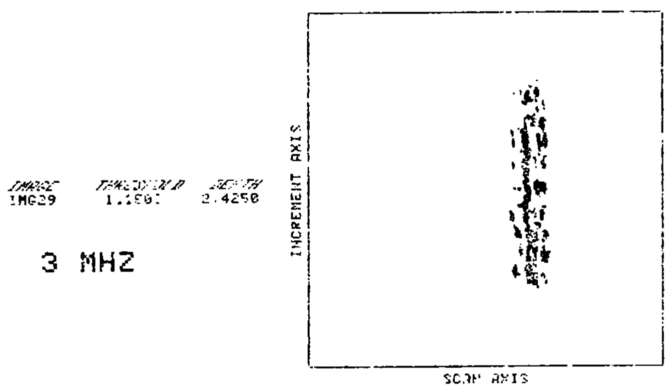
DEFINE S = GRAND SUM OF THE ENTIRE IMAGE ARRAY

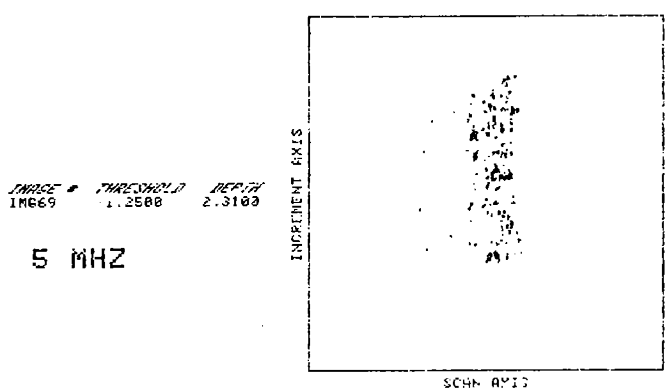
M = MAXIMUM VALUE OF A POINT IN THE ARRAY

T_i = THRESHOLD VALUE

THE RELATIVE PARTIAL SUMS ARE THE SUMS OF THE ARRAY ABOVE THRESHOLDS T_i AND NORMALIZED WITH RESPECT TO THE GRAND SUM.







FIGURES 14, 15, 16: IMAGE CHANGE DUE TO INSPECTION FREQUENCY FOR A NATURALLY OCCURRING ROUGH SURFACE DEFECT